

Attorney Docket No.: 0180199

In the Claims:

Claim 1 (currently amended): A method of fabricating a semiconductor device, having a copper-zinc alloy (Cu-Zn) thin film formed on a copper (Cu) surface by electroplating the Cu surface in a chemical solution, comprising the steps of:

providing a semiconductor substrate having a Cu surface;

providing a chemical solution, wherein the chemical solution comprises at least one wetting agent for stabilizing the chemical solution, wherein the at least one wetting agent is provided in a concentration less than 0.1 g/L, wherein the at least one wetting agent is dissolved in a volume of deionized (DI) water;

electroplating the Cu surface in the chemical solution, thereby forming a Cu-Zn alloy film on the Cu surface, wherein the chemical solution does not etch the Cu surface;

rinsing the Cu-Zn alloy film in a solvent;

drying the Cu-Zn alloy film under a gaseous flow;

wherein the Cu-Zn alloy film has a zinc (Zn) content in a concentration less than 1.0 atomic % such that the Zn content of the Cu-Zn alloy film causes a minimal increase in a resistance of the Cu-Zn alloy film.

Claim 2 (currently amended): A method, as recited in Claim 1, wherein the chemical solution is nontoxic and aqueous, and wherein the chemical solution comprises:

at least one zinc (Zn) ion source for providing a plurality of Zn ions;

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at least one copper (Cu) ion source for providing a plurality of Cu ions;
at least one complexing agent for complexing the plurality of Cu ions; and
at least one pH adjuster, all being dissolved in ~~at the~~ volume of deionized (DI)
water.

Claim 3 (previously presented): A method, as recited in Claim 2, wherein the at least one zinc (Zn) ion source comprises at least one zinc salt selected from a group consisting of zinc acetate ((CH₃CO₂)₂Zn), zinc bromide (ZnBr₂), zinc carbonate hydroxide (ZnCO₃·2Zn(OH)₂), zinc dichloride (ZnCl₂), zinc citrate ((O₂CCH₂C(OH)(CO₂)CH₂CO₂)₂Zn), zinc iodide (ZnI₂), zinc L-lactate ((CH₃CH(OH)CO₂)₂Zn), zinc nitrate (Zn(NO₃)₂), zinc stearate ((CH₃CH₂)₁₆CO₂)₂Zn), zinc sulfate (ZnSO₄), zinc sulfide (ZnS), zinc sulfite (ZnSO₃), and their hydrates.

Claim 4 (previously presented): A method, as recited in Claim 2,
wherein the chemical solution further comprises at least one complexing agent for complexing the plurality of Zn ions being dissolved in the volume of DI water,
wherein the at least one complexing agent for complexing the plurality of Zn ions comprises tartaric acid (HO₂CCH(OH)CH(OH)CO₂H), and
wherein the tartaric acid prevents precipitation of the plurality of Zn ions from the chemical solution.

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Claim 5 (previously presented): A method, as recited in Claim 2, wherein the at least one copper (Cu) ion source comprises at least one copper salt selected from a group consisting of copper(I) acetate ($\text{CH}_3\text{CO}_2\text{Cu}$), copper(II) acetate ($(\text{CH}_3\text{CO}_2)_2\text{Cu}$), copper(I) bromide (CuBr), copper(II) bromide (CuBr_2), copper(II) hydroxide ($\text{Cu}(\text{OH})_2$), copper(II) hydroxide phosphate ($\text{Cu}_2(\text{OH})\text{PO}_4$), copper(I) iodide (CuI), copper(II) nitrate hydrate ($(\text{CuNO}_3)_2$), copper(II) sulfate (CuSO_4), copper(I) sulfide (Cu_2S), copper(II) sulfide (CuS), copper(II) tartrate ($(\text{CH}(\text{OH})\text{CO}_2)_2\text{Cu}$), and their hydrates.

Claim 6 (previously presented): A method, as recited in Claim 2, wherein the at least one complexing agent for the plurality of Cu ions comprises at least one species selected from a group consisting of ethylene diamine "EDA" ($\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$) and ethylenediaminetetraacetic acid "EDTA" ($(\text{HO}_2\text{CCH}_2)_2\text{NCH}_2\text{CH}_2\text{N}(\text{CH}_2\text{CO}_2\text{H})_2$), and wherein the at least one complexing agent for the plurality of Cu ions prevents precipitation of the plurality of Cu ions from the chemical solution.

Claim 7 (previously presented): A method, as recited in Claim 2, wherein the at least one pH adjuster comprises at least one pH-adjusting compound selected from a group consisting of ammonium hydroxide (NH_4OH) and tetramethylammonium hydroxide "TMAH" ($(\text{CH}_3)_4\text{NOH}$).

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Claim 8 (previously presented): A method, as recited in Claim 21, wherein the at least one wetting agent comprises a surfactant, and wherein the surfactant comprises at least one material selected from a group consisting of RE-610TM and polyethylene glycol (PEG).

Claim 9 (previously presented): A method, as recited in Claim 1, wherein the Cu surface is formed by a process selected from a group consisting of chemical vapor deposition (CVD), plasma vapor deposition (PVD), plasma enhanced chemical vapor deposition (PECVD), electroplating, and electroless plating, wherein said solvent comprises water, and wherein said gaseous flow comprises gaseous nitrogen (GN₂).

Claim 10 (previously presented): A method, as recited in Claim 2, wherein the at least one zinc (Zn) ion source is provided in a concentration range of approximately 5 g/L to approximately 25 g/L, wherein the at least one complexing agent for complexing the plurality of Zn ions is provided in a concentration range of approximately 10 g/L to approximately 30 g/L, wherein the at least one copper (Cu) ion source is provided in a concentration range of approximately 5 g/L to approximately 25 g/L, wherein the at least one complexing agent for complexing the plurality of Cu ions is provided in a concentration range of approximately 40 g/L to approximately 100 g/L.

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wherein the at least one pH adjuster is provided in a concentration range of approximately 10 g/L to approximately 20 g/L,

wherein the volume of DI water is provided in a volume range of up to and including 1 L,

wherein the at least one pH adjuster adjusts the chemical solution to a pH in a range of approximately 7.5 to approximately 14,

wherein the chemical solution is maintained at a temperature in a range of approximately 16°C to approximately 35°C,

wherein the Cu surface is immersed for a time duration in a range of approximately 15 seconds to approximately 120 seconds, and

wherein the Cu-Zn alloy thin film is formed having a thickness in a range of approximately 10 nm to approximately 200 nm.

Claims 11-20 (canceled).

Claim 21 (previously presented): The method of Claim 2 wherein the at least one complexing agent comprises ethylenediaminetetraacetic acid "EDTA" $((\text{HO}_2\text{CCH}_2)_2\text{NCH}_2\text{CH}_2\text{N}(\text{CH}_2\text{CO}_2\text{H})_2)$.

Claim 22 (previously presented): The method of Claim 2 wherein the at least one pH adjuster comprises tetramethylammonium hydroxide "TMAH" $((\text{CH}_3)_4\text{NOH})$.

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Claims 23-24 (canceled).**Claim 25 (previously presented):** The method of Claim 2 wherein:

the at least one zinc (Zn) ion source is provided in a concentration range of approximately 5 g/L to approximately 25 g/L; and

the at least one copper (Cu) ion source is provided in a concentration range of approximately 5 g/L to approximately 25 g/L.

Claim 26 (previously presented): The method of Claim 2 wherein the at least one pH adjuster adjusts the chemical solution to a pH in a range of approximately 7.5 to approximately 14.**Claim 27 (previously presented):** The method of Claim 2 wherein the at least one pH adjuster adjusts the chemical solution to a pH in a range of approximately 10 to approximately 12.**Claim 28 (previously presented):** The method of Claim 2 wherein the at least one copper (Cu) ion source comprises copper(II) sulfate (CuSO_4).**Claim 29 (previously presented):** The method of Claim 2 wherein the at least one zinc (Zn) ion source comprises zinc dichloride (ZnCl_2).

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Claim 30 (previously presented): The method of Claim 2 the at least one complexing agent comprises ethylene diamine "EDA" ($H_2NCH_2CH_2NH_2$).